Single-Walled Carbon Nanotubes Studied by Nuclear Magnetic Resonance I

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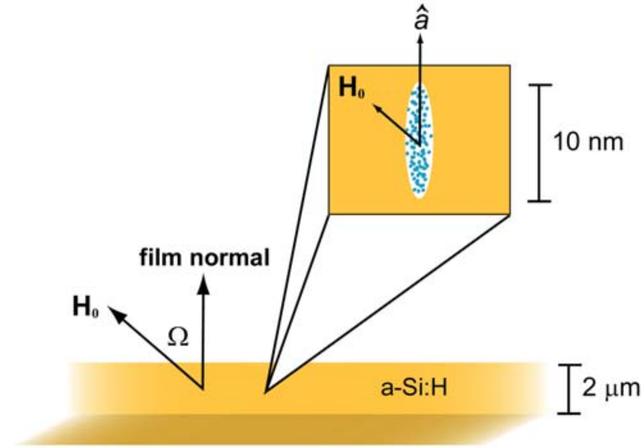
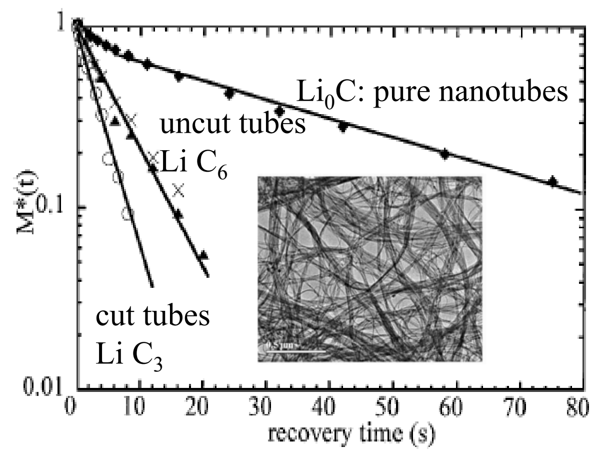
We investigate novel properties of nanostructures in solids and their functions in various applications such as solar cells, fuel cells, and batteries. We discovered that properties of gases in nano-sized containers reflect properties of the containers such as container size, shape, and orientation. Based on this understanding, NMR (nuclear magnetic resonance) was used to reveal and characterize hydrogen gas-filled aligned nanovoids in amorphous silicon film (a-Si:H). This has a direct bearing on improving the energy conversion efficiency of a-Si:H-based solar cells. The figure on the upper right illustrates such nanovoids in a-Si:H. Nano-containers such as carbon nanotubes can also be used for lithium storage. We found that pure single-walled carbon nanotubes can store lithium with lithium-carbon ratio up to Li:C=1:6 which is comparable to graphite. By cutting such nanotubes, therefore opening the ends of the nanotubes, lithium-carbon ratio can be improved to Li:C=1:3 because the inside of the tube becomes available for Li storage. The doubling of Li capacity makes nanotubes a potential candidate as anode materials for lithium batteries with twice the capacity of current lithium batteries. The figure on the lower right shows the NMR signature of such enhanced lithium storage capacity in cut single-walled carbon nanotubes.





Single-Walled Carbon Nanotubes Studied by Nuclear Magnetic Resonance II

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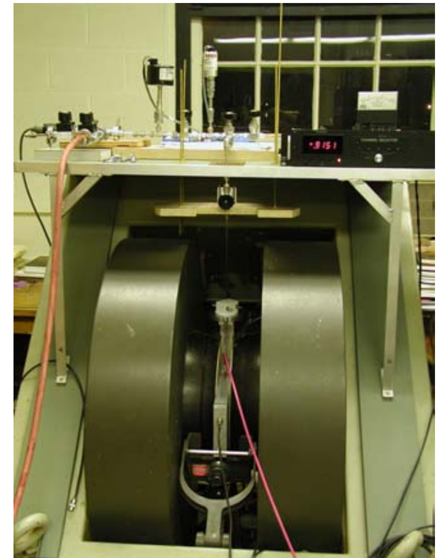
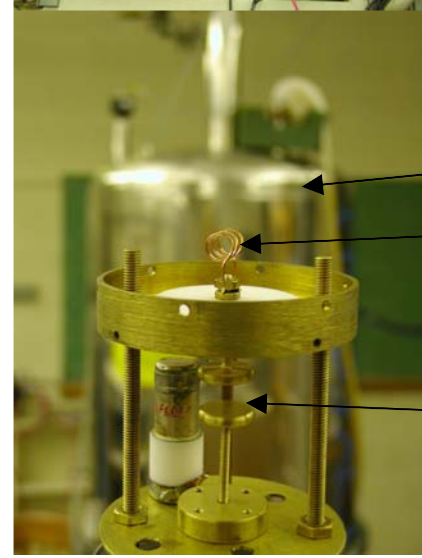
Educational:
2 undergraduates
2 grad students

These students worked at least part time on this project. They learned how to prepare nanotubes and how to load various gases into nanotubes, and how to detect gases inside nanotubes using nuclear magnetic resonance. The upper right picture shows an NMR apparatus with gas loading facility. These students applied their basic knowledge of electromagnetism to build simple, but specialized radio-frequency circuit such as the one shown on the lower right picture to detect nuclear spins. They learned that the sophisticated MRI technology is based on simple physics principles they can appreciate. Some of these students have moved on in their career in areas such as MRI and NMR-based quantum computing.

Nanotechnology and NMR have been incorporated in the teaching of modern physics. Some of the undergraduate students have made significant progress both in research skills and in their course works after joining the research group. Those graduated have gone on to excellent graduate schools.





magnet
inductor
capacitor